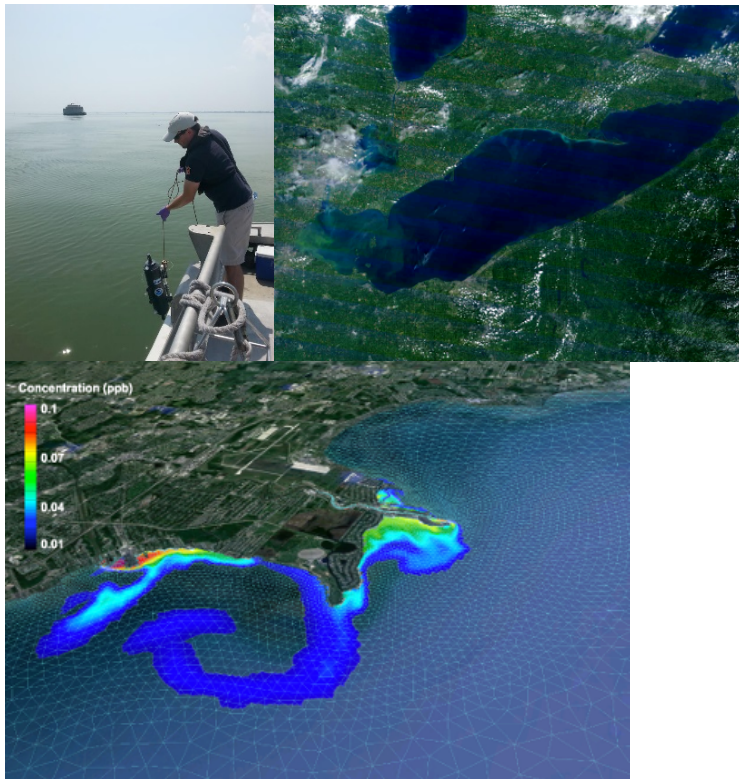


Summary Report

NOAA Great Lakes Environmental Research Laboratory Program Review

March 22nd-24th, 2016



Review Panel:

Dr. Dale Hoff, USEPA – Chair

Dr. Dorothy Hall, University of Maryland

Mr. Thomas O'Reilly, Monterey Bay
Aquarium Research Institute

Dr. Robert Weller, Woods Hole
Oceanographic Institution

Dr. Robert Sterner, Large Lakes
Observatory, University of Minnesota-
Duluth

Dr. Russell Kreis, USEPA

Dr. Ram Yerubandi, Environment Canada

Dr. Kenneth Rose, Louisiana State
University

Overview

The NOAA Great Lakes Environmental Research Laboratory (GLERL) Program Review occurred March 22nd through March 24th, 2016 in Ann Arbor, MI. The panel heard presentations from NOAA leadership on their Agency mission and what GLERL's function is within that construct. This introduction to the Agency and the Division was followed by a series of talks designed to summarize the more detailed research programs of the Ecosystems Dynamics (ED), Observing Systems and Advanced Technology (OSAT) and Integrated Physical and Ecological Modeling and Forecasting (IPEMF) Branches. These discussions were led by Branch Chiefs and Principle Investigators. Prior to the actual review in Ann Arbor, the panel was provided materials from previous reviews and briefed by NOAA facilitators and review coordinators on the process and expectations of the panel. The distribution of information was done primarily through a NOAA review website that provided a convenient means for panel members to access documents.

The panel was very impressed with the depth and breadth of science presented during the review. We would like to congratulate and thank the management, scientists and staff at GLERL for what was obviously an extreme amount of work to prepare for the peer review and describe the information in such concise manners.

Executive Summary

Panelist interactions with leadership and staff at GLERL was very positive and the workforce as a whole was proud of their activities and excited about their jobs. Like many federal organizations, the division has seen a downsizing with poor prospects for replacement of support staff and principle investigators. While residue of challenges in morale from the loss of colleagues was apparent, there was also a strong sense of resiliency and pride in Agency mission.

As outlined and requested by NOAA review coordinators, panel consensus was not a goal for the review. Rather, individual ratings on program Quality, Relevance, Performance and Overall evaluation were provided from each of the panel members (Table 1). The majority of ratings for the 3 Branches were judged by panelists to be greater than satisfactory, reflecting the talent and dedication of the people in the GLERL organization.

This report is organized into sections for each research theme, summarizing comments from individual panelists on the Quality, Relevance, Performance and actionable recommendations for each Branch. The final section provides some comments and recommendations that applied across the division.

Table 1. Summary of the GLERL Review Panel Ratings on Program Quality, Relevance, Performance and Overall Evaluation.

Reviewer		Research Areas													
		Ecosystem Dynamics					OSAT					IPEMF			
		Quality	Relevance	Performance	Overall		Quality	Relevance	Performance	Overall		Quality	Relevance	Performance	Overall
Dr. Russell Kreis		EE	EE	S	EE							EE	EE	EE	EE
Dr. Kenneth Rose		EE	EE	EE	EE							EE	EE	EE	EE
Dr. Robert Sterner		EE	S	EE	EE/S										
Dr. Ram Yerubandi							EE	EE	S	EE		EE	EE	EE	EE
Dr. Dorothy Hall							HP	HP	HP	HP					
Dr. Robert Weller							EE	HP	EE	EE					
Mr. Tom O'Reilly							EE	HP	S	EE					

EE - Exceeds Expectations

S - Satisfactory

HP - Highest Performance

OSAT - Observing Systems and Advanced Technology

IPEMF-Integrated Physical and Ecological Modeling and Forecasting

Research Program Reviews

Ecosystem Dynamics

Quality

The quality of work presented for the Ecosystems Dynamics Research was described by all panelists charged with review of the program as exceeding expectations. The panelists came to this conclusion by citing the number of publications in peer-reviewed, citation statistics of those publications and the division's representation on scientific panels, editorial boards and overall influence on the scientific community of the Great Lakes Region. Also noted was the high number of awards within the scientific community, both internal and external to NOAA.

"Evidence exists from the science presentations, publications, and projected activities through 2020, that quality science will continue to be conducted into the future. Evaluation of efforts on hazardous algal blooms, mussels, and lower food web dynamics suggest that strategic planning on new, innovative and pertinent research areas will continue. Contributions to the scientific community in understanding of these factors have been enormous by this group. EcoDyn publications represent the highest quality and number overall for NOAA-GLERL and similarly represent the greatest H-index scores for both current and emeritus personnel. Several awards and honors have been received recently by EcoDyn staff, but relatively less than other research theme groups. Data provided indicate that scientific activities with other scientific groups and with respect to outreach and education are sufficient. Service to the scientific community is noted, typically through guest editorships and journal article reviews, but few elected offices are held in these arenas. International cooperation with Canada is mandatory with respect to Great Lakes research and is evident."

"This division produces high quality products as evidenced by the publication record and external and NOAA extramural awards history of the members. Quality is also measured by the respect given to the members from outside for scientific input and evaluations. The members in this branch are highly active in many Great Lakes committees and advisory panels. They are also active on editorial boards."

"Raw bibliographic measures of productivity are far from perfect measures of quality of research, but the information can be relevant. The 4 most senior scientists in the EcoDyn group number among GLERLs most published and most heavily cited. This might be because of a wider audience for these papers than for some of the other GLERL scientists but nevertheless it does indicate significant contributions made by this group. In my experience, recently highly influential papers that the EcoDyn group has contributed to includes broad assessments of the Ecosystem Services of the Great Lakes, holistic studies of changes in Lake Erie water quality, and studies regarding the biology of toxic cyanobacteria. EcoDyn researchers led some of these most cited studies and contributed as members of large teams to others. EcoDyn scientists are among the most influential working in the Great Lakes today."

Relevance

Overall, the panelists believed that the ED Research program was well aligned with NOAA strategic plans and provided relevant data and interpretations for Great Lakes environmental management decision makers. It was recognized that the division is part of an on-going period of transition at multiple levels within the NOAA organization. While many demands on the ED

research program are historic and will be needed to be maintained, the division is also working to reflect the national initiatives outlined by the Agency's senior leadership.

"The EcoDyn Theme exhibits alignment to NOAA and OAR mission, goals, and strategic plans through Healthy Oceans, Climate Adaptation, and Resilient Coastal Communities and Economics. The efforts reflect relevant investment and relevance to the Great Lakes, scientific community, and buy in by stakeholders. Stakeholder comments from Brian Miller were very positive with respect to collaborative efforts with Indiana-Illinois Sea Grant and efforts on Lake Michigan lower food dynamics. In addition, the GLANSIS system and communication appears to be intimately tied to Sea Grant. The Great Lakes Fishery Commission provided substantial comments on the importance of NOAA-GLERL efforts in fisheries management. Specifically mentioned were ecosystem research and models related to the lower food chain, larval fish, and Asian Carp. The Cleveland Water Department similarly expressed appreciation of efforts regarding hazardous algal blooms and hypoxia and the different investigations that influence how the water plant operates."

"Under the new lab leadership, there is a major effort to align the branches' and Lab's activities with NOAA's mission. This is exemplified in the new strategic plan. Within this branch, the research topics addressed fluctuate as a function of outside demands, but also the personnel present and the availability of funding. This always leads to a gap between the projects and how they fit with each other and to the broader goals. At the Lab-level, this is being nicely addressed with the new strategic plan and could always use more effort to how past and ongoing projects fit together. GLERL does this better than most places, especially Universities, which I have reviewed so this is a gentle urge to keep at it (especially as a Federal unit) and not a criticism."

The branch is exceptionally well tuned into the past, present, and emerging issues within the Great Lakes. The topics presented included rationales why they were important and, combined with the feedback from the stakeholders, clearly showed that the individual research topics were undoubtedly highly relevant.

"The EcoDyn group identifies its alignment with NOAA's mission especially in the goals of Healthy Oceans, Climate Adaptation, and Resilient Coastal Communities. It was most apparent during the review that alignment with Healthy Oceans was particularly strong but HAB work aligns almost as strongly with Resilient Coastal Communities."

Performance

Performance ratings by the panel for the ED research program were generally satisfactory. Comments from the panelists consistently commented that each while each of the projects were "scientifically meritorious" and performing at a high level on an individual basis, but what seemed to be missing in moving toward an exceeds expectations or outstanding rating was linkages among the seemingly disparate projects.

"Paths and milestones laid out in the Strategic Plan are scientifically meritorious, compliment long-term investigations and expertise, exhibit adaptation with new hypotheses, and indicate innovative changes for the future. It also signals effective planning, research leadership, and engagement in the process."

"The presentations were excellent and showed that the branch has top level scientists leading their projects. One observation is that rarely were hypotheses (or research questions) stated that linked to other ongoing projects, and even to projects on the same topic performed in the past."

There is excellent participation of people advising students and serving as adjunct faculty at universities. The benefits from this are difficult to quantify, but they are very worthwhile.

“Based on the presentations and material provided, all areas of focus seem to be progressing well”

“My impression was that the group was composed of very strong separate parts and a potential opportunity for leadership in the group was further pulling those pieces together into a more coherent whole. The group clearly is highly capable in terms of lining up and coordinating resources to support a great deal of scientific research. Articulating hypotheses, questions or goals that all members of the group can contribute to while pursuing their individual studies would increase both efficiency and effectiveness.”

Actionable Recommendations:

Independent recommendations from the review panelists were consistent and generally fell into 5 categories:

1.) There is a need to maintain current and evolving comprehensive hiring strategies for backfilling retiring staff. There was no staffing plan or hiring strategy provided to the panel for review although mentions of such a plan existing was made on a couple of occasions. As retirements occur, the senior leadership of GLERL should take those opportunities to back fill those positions (when possible) with a balance of federal principle investigators AND support staff. Senior leadership should be leery of relying too heavily upon cooperative agreements such as that with CILER for senior science leadership and support.

“The branch seems to have a good relationship with CILER, perhaps even too good in terms of some key people within the branch actually being long-term CILER employees. These employees have less security and staying power than Federal employees. **Steps to ensure institutional memory is preserved, such as a common database and synthesis teams can help any rough transitions (e.g., multiple departures or retirements at once; changes in funding to CILER).**”

“Maintain a high priority for hiring in the area of phytoplankton/primary production. The group has good expertise in cyanobacteria but the rest of the base of the food chain needs attention. The succession/staffing plan indicates a priority topic of Primary Production/microzooplankton. This reviewer concurs with that being a priority for this group because of the importance of primary producers to water quality and ecosystem dynamics.”

“For succession planning, a phycologist/primary producer position and another biogeochemical modeler position should be high priorities.”

2.) The Branch should improve public accessibility to data and models. Key data sets from long term monitoring programs are not easily obtainable for the public or outside scientists. While the panel cannot provide a list of those data sets not easily obtainable, questions posed to several presenters and other scientists indicated that while staff at GLERL are happy to share information and make data available upon request, the data are not readily available for general scientific or public utilization.

“The quality of the research is very good to exceptional at the investigator and project levels, but there is room to increase quality by **providing easy access to key datasets with a formal database system.** Not all

data from every experiment needs to be cataloged; rather, the key datasets that could inform a variety of projects, have legacy appeal, and can provide the basis for study design, proposal preparation, and cross-investigator and cross-project synergisms. One of multiple possible examples is the long-term research monitoring data set.”

A comparable inventory of models, with fairly detailed information about structure, purpose, skill assessment, critical need, etc. can also be created. This can help future investigations and also be used to show the modeling skills and tools of the branch and lab.

“Establish a plan to address documentation, archiving, and accessibility needs for the long-term data collection, then work with the institution to identify resources to turn this asset into something the broader ecological and limnological community can utilize. An institutional investment to clean up the historical data, and combine it with a much improved front end for serving newly collected data to the public would be a wise investment.”

3.) The ED research program should seek to broaden its scientific publishing audience and scientific community involvement outside of the Great Lakes area. While the work done by scientists within the ED research program is well known and respected within the Great Lakes community, seeking a broader scientific audience would increase the visibility of the group and division nationally and internationally as well as potentially provide insight to research questions that may be needed in the future for the Region.

“Participation on national and international boards and advisory panels would increase visibility on the research topic themes, which all have implications beyond the Great Lakes.”

There are several topics I expected to hear at the project-level that were noteworthy by their absence or limited mention. These are: (a) ecosystem-based management, (b) ecosystem-based fisheries management, (c) ecosystem services (a little), (d) coupled human-natural systems, (e) integration and synthesis (not just how the projects fit together within Lab and NOAA but how the science methods and results come together), (f) database development, (g) high performance computing resources, (h) zooplankton dynamics, (i) uncertainty and risk analysis, and (j) overarching but detailed conceptual models of how key components of the ecosystem interact to which projects methods and results can be mapped. The last item was also noted as recommendation on the previous review (#10 in the GLREL response).

Some additional consideration of these topics that I encountered nationally and internationally, some may not be major issues within the Great Lakes, could help ties projects together and start people thinking about next the five years.

4.) The ED Research program should seek to improve the unit’s scientific connections and cohesion among projects within the group. As new projects are developed, principle investigators and branch chiefs could present proposals to the branch and seek opportunities for cross-pollination.

“Overall, my assessment is the EcoDyn group is involved in high quality separate studies. They do certainly already have connections across these separate pieces, but the “sum of the parts” did not appear to be their strength. With some relatively new members of the group and with potential succession bringing even new perspectives and talent into the group ahead of them, the timing seems right to explore more thoroughly how to draw tighter connections within the group.”

5.) The panelists noted that this program had a particular skill mix conducive to high quality work in modeling lower food chain dynamics. However, modeling of higher trophic position species was also apparent and may even be duplicative with other federal resource management agencies (e.g. USGS). While it is certainly the prerogative of branch and division to invest resources into future research efforts, the panelists would urge the research program to consider some of their core strengths in prioritizing future research efforts and partner with other federal agencies to complement those strengths.

“Ecosystem modeling and forecasting must be advanced with respect to lower food chain dynamics, interaction with nutrients, invasive species, hazardous algal blooms, and *Cladophora*.”

“Identify strategies for “scaling” biological knowledge from the individual or population level to the system level. What detail should be prioritized and how can it be used in future modeling efforts?”

“Some additional steps to ensure that long-term projects allow for the cycling of data to model to data (i.e., the iterative process) maximize these opportunities should be considered.”

Observation Systems and Advanced Technology

Quality

The quality of work presented for the Observation Systems and Advanced Technology Research program was described by panelists charged with review of the program as exceeding expectations and at the Highest Performance level. The group is developing and/or utilizing innovative current technology that is responsive to the needs of biologists and scientists providing data for a diverse set of field studies and model inputs. OSAT has successfully developed successful relationships and partners within and outside of government to help maintain cutting edge technology. Researchers in the group are published and have received awards from within and outside of NOAA.

“OSAT scientists are involved in a number of very important endeavors, involving not only research, but also involving the practical applications of running NOAA programs such as CoastWatch for Decision Support. They are well versed in current satellite technology and are involved in developing key instrumentation to improve monitoring of ice and biological entities such as algal blooms. OSAT scientists are also involved in important areas of innovative research involving the use of remote sensing and in-situ instrumentation.

“The engineers are very responsive to the needs of the PIs who are designing field work.”

“In addition to the USCG and the GLRI, OSAT scientists have developed good collaborations with outside-NOAA entities such as the University of Michigan, Michigan State University, University of Toledo and Ohio State University. This allows OSAT to keep at the forefront of technology and relevance.”

“A small group with diverse responsibilities. In many areas they are at the leading edge: green ship, planning for a new regional vessel, remote sensing, water quality/nutrients/hypoxia monitoring, working in the winter, planning for year round, bottom mounted observing. Developments of ESP lander and

bottom mounted winch show capability. Fielding, maintaining, and growing ReCON is an impressive effort for a group this size.”

“OSAT team has developed systems and successfully transferred them to operations. ReCON buoys, met stations, networking software and other components have been transitioned to GLERL operations, NWS, NBDC, and other entities. HAB and hypoxia monitoring/warning systems developed under SOAR have been transitioned to operational use by GLRI. Team is evaluating new technologies that potentially reduce costs, e.g. Wave Glider, UAV hyperspectral imager, third-party sensor software, emerging standards for sensor interfaces. OSAT collaborates with NBDC, CILER, GLOS. Senior team members were given awards by NOAA and NASA in recognition of their work.”

Relevance

The relevance of OSAT research was judged by panelists to either Exceeds Expectations or at the Highest Performance level. Of all the research programs at GLERL, the OSAT group seems to be most linked into leadership roles of providing services for several monitoring networks and providing key data for local, State and regional environmental managers. Research conducted by OSAT is consistent with Agency mission and relevant to Agency Leadership Agendas. Stakeholder comment on products delivered by the OSAT research program was overwhelmingly positive.

“OSAT personnel are involved in a number of important issues such as HABs, ice extent, SST for fishing-related applications, etc. These critical issues are an integral part of NOAA’s strategic plan. These issues are directly relevant to the lives and health of people living in the larger Great Lakes watershed (and elsewhere).”

“The Great Lakes CoastWatch node is a tool of major importance used by NOAA and many others (e.g., the USCG) as well as the media and even the general public to learn about the status of the Great Lakes in near-real time. It is of upmost importance to continue and expand the CoastWatch site and to make it as user friendly as is possible.”

“OSAT scientists have a well-considered approach to studying HABs with the objective to enhance predictive models that forecast bloom size, location and toxicity by combining satellite and in-situ measurements, and modeling.”

“One very much sees that GLERL is in the right place at the right time, and that a capable and effective OSAT is a key element of GLERL. The water level, water quality, invasive species, fisheries management, support to navigation and SAR issues in the Great Lakes are real and pressing. Stressors in addition to climate change and the close proximity of large cities and societal dependencies on the Great Lakes present very relevant issues to be addressed. Growing the observing capability, in coverage across the Lakes and over the full year, is an important highly relevant mission for OSAT and GLERL.”

“Stakeholder feedback on GLERL was very positive”

“OSAT activities are well-aligned with NOAA strategic plan and goals, and are societally very relevant. Stakeholder comments regarding OSAT are overwhelmingly positive, with only minor stakeholder recommendations for improvement.”

“OSAT’s core research and technical services supports NOAA’s strategic goals well, for eg: supporting research and operations required for forecasting or improved understanding of ecosystems and prediction of HABs and Hypoxia in Lake Erie. Their operations group is critical for maintaining buoys, platforms and data management i.e., real-time data communication through information portals such as GLOS and transmitting through NDBC etc. Their work is directly relevant to coastal communities (for eg: Cleveland drinking water intake). Their vessels group is well placed to support activities in many of the Great Lakes. Presentation from the group lead (Ruberg) demonstrated these aspects very well. Their main customer base is internal NOAA/NOS/NWS and other groups in GLERL (ecodyn and modelling groups) and CILER.”

Performance

Panelist reviews of the performance of the OSAT research program ranged from Satisfactory to the Highest Performance level. Reviewers judging OSAT’s performance above Satisfactory noted that while the group is small in size, they are expanding the technological capabilities of the Division for a broad research portfolio. Reviewers rating the group as Satisfactory, noted the lack of specific technology such as radiometers on buoy systems and minimal engagement of scientists and engineers outside of the Great Lakes Region as factors challenging the group’s overall performance.

“OSAT is responsive to, and working toward the goals from the 2016 – 2020 GLERL Strategic Plan. They are expanding their use of technology, both remote sensing and in-situ (including marine platforms and instrumentation). Marine vessel support is a huge and critical task. They have a 50-year strategy for addressing gaps in vessel issues.”

“GLERL scientists of OSAT are frequently called upon to provide expert analyses to news entities and the public. This is very time consuming. In concert with scientists from other GLERL themes, they do an excellent job of carrying out NOAA’s core mission and conveying scientific results and ice and algae updates to the general public. Working with partners such as those at GLOS and the USCG, they respond to partners’ needs and the curiosities of the general public.”

“On research leadership – OSAT is a small, diverse, talented group with a rather broad portfolio. Many activities clearly address the needs of the GLERL science teams, but an over-arching prioritization and guidance of OSAT efforts to address the needs of the ecosystems and IPEMF teams was not apparent. Is OSAT a stand alone team that addresses NOAA-wide goals and objective or does OSAT address the needs of the ecosystems and IPEMF teams. It was stated in the overview presentation that OSAT addressed the needs of the other teams. Yet, the lack of observing the incoming radiation and the measurement making done in other groups suggest a lack of full integration.”

“Efficiency and effectiveness – for a group this size to do what they do and lacking resources such as an in-house machine shop, it is impressive. However, awareness of the same or similar work done at other labs can make OSAT even more effective by being able to adopt rather than develop in house needed technologies and capabilities.”

“FY Annual Operating Plan document appears to provide good detail on project goals, rationale, planning, and evaluation. OSAT engineers seek technical advice from collaborators at other organizations..... It seems clear that OSAT is generally effective in transferring products (e.g. based on stakeholder comments), but not clear how efficient. Radiometric measurements over lakes are critical for assessing

energy balance, but while integration of radiometers with buoys is planned it's not yet widely implemented."

"OSAT's ongoing research and operations plan on the remote sensing and real-time water quality monitoring buoys highlights the collaborative leadership of this group. The group is relatively small in number (8 team members) but complemented well with CILER staff on most of the projects. OSAT is currently expanding their traditional remote sensing products to the current needs on the Great Lakes (for eg: chlorophyll_a and cyanobacteria retrievals)."

"The presentations from the group demonstrate that they need to work with several internal and external researchers to enhance and develop technologies to better observe the lake ecosystems. The amount of technology transfer to operations from this group is impressive given that this group was only established into a separate theme only after the last Lab review. However as new and different technologies are being considered (for eg: autonomous vehicles or ESP etc) it is important to ensure through the research first that they are necessary and relevant for operations in the Great Lakes."

"NOAA's Lake Michigan Field station operates vessels of different sizes and it is one of the critical parts of GLERL's successful field campaigns. The future plans of this group, for eg: getting new personnel, retrofitting older ships and boats to accommodate new technologies should be a high priority. GLERL is slowly moving into new ways of monitoring for eg: coastal RECON platforms, the vision seems to be good but the goals need to be further developed for eg. on the year round operation through cabled networks GLERL need to clearly articulate the benefits of such nodes and how they tie into the primary focus of ecological forecasting or other applications. I understand the need for year-round (under ice) measurements of some parameters, but clearly the current issues in the Great Lakes like summer time HABs and hypoxia, which are focus research areas of GLERL, have to be kept in mind before moving resources into these kind of activities."

Actionable Recommendations:

Recommendations for the OSAT Research Program generally fell into 4 categories:

- 1.) Performance within OSAT could improve by incentivizing non-research engineers to publish in appropriate journals of their expertise and for scientists that are publishing to diversify their journal contributions and target audiences beyond JGLR. Overall, panelists were impressed with the technology developed and utilized at GLERL, but their work is not generally benefitting science audiences unfamiliar with JGLR. Similarly, OSAT engineers are encouraged to increase efforts to reach out to organizations in Canada of similar research interests in the Great Lakes to exchange innovative technologies and maximize coverage of monitoring in the region.

"Diversifying publications into different journals as well as keeping up a steady stream of publications into JGLR is a desirable goal. "

"Encourage OSAT non-researcher engineers to co-author descriptions of their approaches and innovations to peer-reviewed journals such as the IEEE Journal of Oceanic Engineering. Such publication would contribute technical knowledge to the community, enhance GLERL technical standing, and provide recognition and encouragement to individual engineers."

“Increase the cross-pollination of OSAT staff and technologies with NOAA labs and academic institutions with similar effort. If NOAA travel restrictions prevent or limit the ability of GLERL staff to travel to key meetings and/or to visit other labs, GLERL/CILER should work with NOAA OAR to host workshops at GLERL, pulling in other NOAA lab staff and Cooperative Institute staff to GLERL.

“OSAT engineers are in the response mode out of necessity, to support the various core programs. They would also benefit by gaining familiarity with new and innovative technology. This may be occurring but was not completely evident during the presentations.”

“Given that the Great Lakes are a shared water body, and it is difficult for any country’s agency to cover all the lakes in a given time, GLERL management should encourage their OSAT staff to actively coordinate their monitoring plans with Environment Canada and other agencies in Canada. I also encourage GLERL staff to enhance their collaborations with other premier research institutes and universities for developing novel research technologies.”

“GLERL’s field based work is strong in Lake Michigan and Lake Erie, and they have some presence in Lake Huron. To take active role in the Great Lakes Water Quality related monitoring, this need to be expanded beyond these lakes.”

2.) OSAT should ensure that buoy monitoring systems have core technology capable of reporting key parameters that are a standard fare outside of this research group. The specific example given by panelists was instrumentation capable of measuring and reporting short and long-wave radiation. However, as engineers reach out to external entities, other endpoints of import may be discovered and incorporated.

“On the instrumentation side, there is a need for additional parameters to report (for eg: short and long-wave radiation on their buoys is not very difficult).”

“OSAT should put high priority on radiometer integration with RECON buoys, as these instruments provide critical fundamental over-lake energy balance measurements. “

3.) Continue to ensure strong interactions between research scientists and engineers. If not already occurring, OSAT engineers should promote their innovative approaches within the other two branches such that new research questions may be developed through opportunities borne from their technological advances.

“OSAT is a large and diverse theme. It almost seems as if there is somewhat of a disconnect between the scientists who are conducting research and the rest of OSAT. In other words, I wonder if the scientists might be better-served to be in another theme where the science is the key “product.” This is not a criticism, but an observation. It shouldn’t matter which theme a scientist is in, if there is adequate interaction among scientists and engineers between themes.”

“Develop a GLERL-wide strategic plan for observing, motivating growth in coverage and/or in capability by the science and societal drivers outlined by the ecosystems and integrated physical-ecological modeling and forecasting teams but also having OSAT indicate where new technology may open doors to new science in the other teams.”

“Although it is desirable for the technologies like buoys developed in GLERL are transferred to partners, the dependency on industrial partners like Limnotech for their long-term operations is not an ideal situation for long-time monitoring of the lakes, and NOAA should find ways to manage these internally or in collaboration with other federal agencies.”

Integrated Physical & Ecological Modeling & Forecasting Research Program

Quality

All panelists charged with review of the IPEMF research program judged the Quality of work conducted in the Branch as Exceeding Expectations. The reviewers noted innovative and original research conducted in IPEMF proven to be of high value to Regional stakeholders. The group has had a strong publication record with researchers having high H-Index factors in high quality journals and there is a strong record of participation and leadership in professional societies. Bodies of work from the IPEMF research program have been recognized with distinguished awards.

“Their lake hydrodynamics and net basin supply modeling work is of very high quality, and GLERL is the first agency in the Great Lakes region to provide model based lake forecasts on a daily basis, which is being used by several customers in the Great Lakes region. Some of the testimonies we heard from the stakeholders confirm the importance of these products.”

“GLERL is continuing its high quality hydrological research demonstrated in a high-impact publication in Science. This group has provided excellent leadership in coordination and operationalization of water level model and evaporation network on the Great Lakes, which is a critical element in closing the water balance of the Great Lakes. Ecosystem modeling contributions have made it into policy applications in developing new nutrient targets for Lake Erie.”

“In the Great Lakes ice modelling has not received significant attention in the past, Wang and his colleagues in CILER are one of the first researchers in this area and their contributions to the next generation hydrodynamic models are really of high-quality.”

“Provided information from the science presentations, publications, and projected activities through 2020 indicate that quality science will continue to be conducted into the future. IPEMF publications represent a high quality and number overall for NOAA-GLERL. Generally very good H-index scores exist for both current and emeritus personnel; in one case, the IPEMF staff scored the highest in most recorded categories. Several awards and honors (some high level) have been received recently by IPEMF staff and is very good, although some recognize primarily an emeritus staff member.”

“Evaluation of efforts regarding hydrodynamics models, ice research, efforts on hazardous algal blooms, and other biological factors suggest that strategic planning on new, innovative and pertinent research areas will continue. Contributions to the scientific community and other stakeholder groups in the understanding of Great Lakes hydrodynamics have been enormous by this group through the past decade.”

“Data provided indicate that scientific activities with other scientific groups, outreach and education are sufficient. Service to the scientific community is noted, typically through guest editorships and journal article reviews, but few elected offices are held. International cooperation with Canada is mandatory with

respect to Great Lakes research and is evident. In addition, the IPEMF group appears to have national, as well as world-wide representation and exposure in working groups and meetings.”

“This branch is very much targeted at moving their modeling tools from research to operations. Within that context, the IPEM keeps careful and clear tracking of the status of their models. They seem to be quite successful and are on a good path going forward.”

“A considerable number of high quality work products (publications) were delivered by this group and a considerable number of awards were also received by this group. International representation by this group is evident.”

Relevance

Panelists charged with review of the IPEMF research program judged the Relevance of work conducted in the Branch as Exceeding Expectations. All reviewers noted the strong alignment of the research program with Agency mission, goals and strategic plans. Stakeholder input for the Branch was overwhelmingly positive and it was very clear that the models developed in the program are highly utilized in the Great Lakes Region. Especially meritorious was the rapid response in which the research program has toward hazardous algal blooms threatening drinking water supplies of the Great Lakes communities. IPEMF scientist participation and leadership roles on binational committees within the GLWQA was also noted.

“The IPEMF Theme exhibits alignment to NOAA and OAR mission, goals, and strategic plans through Healthy Oceans, Climate Adaptation, and Resilient Coastal Communities and Economics. The efforts reflect relevant investment and importance to the Great Lakes, scientific community, and buy in by stakeholders. These generally encompass IPEMF efforts on hydrodynamics, hazardous algal blooms, and ice research.”

“Overall, the IPEMF group is working on relevant scientific topics which are important to the Great Lakes Science community, stakeholders, and to the public. The rapidly evolving and pressing needs surrounding hazardous algal blooms are being addressed with multiple efforts and innovation in IPEMF and the other GLERL branches.”

“Stakeholder comments were received from The Great Lake Observing System, U.S. Coast Guard, U.S. Army Corps of Engineers, Ontario Power, and Cleveland Water Department which all discussed different aspects of IPEMF efforts. Overall, all comments were very positive IPEMF has extremely high stakeholder support across a broad spectrum of federal, local-private sector, and academic groups and reflects relevance.”

“The linkages to NOAA and the Lab’s strategic plan are very strong, in part, because of the goal of operationalizing models. The stakeholders (while not randomly selected) praised the products and responsiveness of the models from this branch. My brevity here is simply because the drive towards operational models aligns the branch’s efforts clearly with NOAA and the Lab’s mission and objectives.”

“This group’s work is highly relevant to NOAA’s strategic goals for eg: weather ready nation, climate change and adaptation and Healthy Oceans. The research and operational products from this group are directly relevant to many stake holders. Many people spoke high of these activities, for eg: Coast Guard’s search and rescue, water levels coordination, outflow regulation etc. More recently, GLERL is expanding into HABs and Hypoxia predictions, which would expand their traditional customer base.”

“GLERL scientists also played an important role in bi-national committees in developing nutrient targets for the Great Lakes, and I am pretty sure GLWQA would still require their help in implementing the adaptive management plans.”

Performance

As with the other two categories under consideration, panelists charged with review of the IPEMF research program judged its Performance as Exceeding Expectations. The IPEMF Branch has apparently successfully endured a series of transitions and retirements of senior scientists and management. In spite of these transitions, solid research planning and leadership are in place and performance has not declined. In many ways, the performance of the IPEMF research program reflects the overall performance of the division as it is an integrator of data collection and modeling efforts of the other research groups. In this role, IPEMF appears to be excelling.

“As provided in the Strategic Plan, paths and milestones laid out in the Strategic Plan are scientifically relevant, are consistent with expertise, have a focus on moving specific model constructs to “operations”, exhibit adaptation with new research areas for the future, and has a demonstrated ability to transition and sunset certain project areas. These indicate effective planning, research leadership, and engagement in the overall process.”

“There does not appear to be any computational power or storage capacity issues facing this group at the present time.”

“This branch has largely satisfied recommendations from the previous review. However, the recommendation to couple physical with ecological models is still developing and has not been fully realized the potential that is present.”

“One of the lab-wide, cross-theme research areas is hazardous algal blooms and this group appears to be in a position to continue to make monumental contributions to this issue. Efforts on HABs and the Lake Erie HABS tracker and related IPEMF efforts on physical modeling and forecasting should be continued.”

“One of the lab-wide, cross-theme research areas is ice research and modeling. In my estimation the IPEMF group is the lead on this project with clear cross-over with OSAT. This project encompasses hydrodynamics, circulation, hydrology, water levels, over-water atmospheric events, meteorological events, storm surge, waves, wind, evaporation, water loss, precipitation, surface water temperature, air temperature, and ultimately impacts the overall need for efforts on climate change. In addition, these conditions may have distinct effects on coastal communities. These aspects of mission and goals are also supported by the various stakeholders interviewed during this process.”

“First of all, I should congratulate the Director, GLERL and her team in presenting their programs in great details in the short time frame. I think IPEMF, GLERL team did a very good job in preparing for and presenting their objectives of each of their projects. The team is very passionate in what they are doing and their productivity shows well. I also appreciated follow up chats I had with some of the scientists in IPEMF. GLERL has been a leader in the hydrodynamic modelling of the Great Lakes, because of the retirement of senior staff like Dave Schwab and Tom Croley and re-organization of themes after the last review I was a bit concerned that they might be losing that edge. However, GLERL has demonstrated that they have a clear plan on enhancing their research models under new leadership, for eg: migration to

FVCOM to resolve coastal regions more accurately and transitioning this research to operations is really a positive step. I encourage the team to actively do the skill assessment of this system as it has the potential to become critical for many stakeholders.”

“GLERL has developed a good reputation in the region and they work very effectively with users for disseminating their products, and IPEMF and OSAT are the main groups in delivering those. However their collaborators are mostly limited to either other NOAA services or a few municipalities and data management systems like GLOS. There are lots of opportunities for GLERL to significantly improve their influence across the border also provide guidance to the teams working in other large lakes of the world. From OSAT group several remote sensing and *insitu* data products were presented, clearly some of these data could be relevant for data assimilation for lake hydrodynamic models or for improvement in representation of physical, chemical and biological processes, but no researcher from IPEMF discussed about this important aspect. Clearly data assimilation has to be considered for this group’s short-range predictions. “

Actionable Recommendations:

The reviewers of the IPEMF research program had recommendations falling into four general categories:

- 1.) IPEMF should maintain and expand topical modeling expertise. Specifically, the very relevant and ongoing research and expertise in hydrodynamic modeling should be maintained while expanding the expertise in the group with ecological/ecosystem modeling. As a group charged with integrating the expertise of the division, the omission of ecological/ecosystem modeling expertise in the group is quite notable.

“The primary expertise, long term experience, and emphasis of this IPEMF group is hydrodynamic-hydraulic modeling. This forms the basis for a number of activities and must be retained as a central and critical expertise.”

“Ecosystem modeling and forecasting must be advanced within the IPEMF in collaboration with the EcoDyn group with respect to lower food chain dynamics, interaction with nutrients, invasive species, hazardous algal blooms, and *Cladophora*. For succession planning, another biogeochemical/ecological modeler position should be a high federal hiring priority.”

“HABs tracking, research, and model forecasting is a lab-wide research area and ecosystem modeling should be escalated in this area.”

“IPEMF provides important services to many stakeholders and their research is highly relevant to the current Great Lakes water quality and quantity issues. Although GLERL has highly motivated staff to address physical component of the system, clearly there is a need for a staff bio-geochemical modeler who can integrate the physical part of the models with the knowledge gained in ECODYN group.”

- 2.) Developing models to their “operational” stage is a clearly identified goal of the IPEMF Research group. While this may be the ultimate goal of many of the deliverables produced by the Branch, the level of effort and research conducted to get to that goal is high while the level of visibility and documentation of those efforts are relatively low. While the panelists recognized the challenges involved with increasing the visibility of these efforts, they none-

the-less encouraged researchers within the group to identify intermediate stages of model development to publish results of model testing and scenario building as a way to describe the “science of going operational”.

“The publication record is strong but not exceptional. For example, they have one of six people with an H-index greater or equal to 20. This is just a qualitative indicator and should not be over-interpreted. It simply puts a little context to the pattern. This branch faces a challenge of pushing models towards operational use, which is not always the shortest path towards also generating peer-reviewed publications. There is a trade-off between modeling to address scientific questions versus bringing models to the operational stage. There are enormous efforts involved in ensuring QA/QC, documentations, performance, etc. to get a model into operational usage. **Somehow, and I not sure how exactly, the drive to operationalizing should continue but also the science learned from the modeling and making it operational should also be published.**”

“An area this branch may consider putting more effort into, especially in terms of publication, in the “science of going operational.” Scenario analyses of what steps in going operational the challenge the modeling, what happens to performance and skill if only certain of the steps are successfully completed, and going back to re-evaluate the performance of operational models to see if other steps could improve performance. This would keep the main thrust operational but get more into the methodology rather than simply following the method. This does not need to be limited to operationalizing models; how about how the performance of models deviates when they are for biological and ecological purposes? Such uses often move the physical model away from what it developers were focused on, and yet the ecologists assume the physics is exactly correct when they use the results.”

“The goal of transiting models per a schedule to “Operational” is an exemplary, yet ambitious goal, and should be pursued as a high-visibility delivery of GLERL products with specific mission implications within OAR and NOAA.”

3.) All panelists had comments recommending improved coordination with the IPEMF branch with other Branches in the Division; especially given the name of the Branch and its identified mission. While this certainly was not a common theme across all research efforts (HABs forecasting being an obvious example to the contrary), reviewers believed more should be done to increase collaborations among the Branches such that the integrated modeling efforts would harvest appropriate information for modeling efforts. Similar to recommendations in other research groups, reviewers recommend developing mechanisms to increase the potential for interaction and sharing of information at the project planning and development stage of model development.

“While this branch deals with climate in their modeling, this is an area ripe for expansion ad collaboration. Some type of collective set of scenarios and results about climate into the future that can be used Lab-wide would be very useful, as would this branch providing specific information to the projects of the Ecosystem Dynamics branch. Also, **given the title of this branch, I was expecting some mention of end-to-end modeling, which is an emerging area often couched under Integrative modeling.**”

“There are particular strong foci within the branch, including ice, hydrodynamic, hydrological, climate, and water quality (nutrients, HABs). I am aware of the excellent reputations of the ice and water quality

modeling within and outside the Great Lakes community; I simply do not know about the reputation of the lake hydrological and climate modeling (very likely is good). The coupled multi-lake modeling is a good example, among many, of what seems like a promising direction. Similarly, the collaboration with the Quagga mussels with the Ecosystem Dynamics group is a good example of consistent use of models across projects. **More such efforts that push the modeling within the branch and encourage cross-fertilization with other branches should be encouraged.**

“This branch seems detached from the other two branches (the integrated part). I believe there are examples of this branch monitoring for their own data and also examples (albeit not always) the Ecosystem Dynamics branch using physical models (not from this branch) in their analyses. I am not suggesting that every use of a physical model must be the exact implementation across all projects and branches. However, the potential for inconsistency in how the same physical systems are modeled can, if not carefully tracked and assessed, impact the quality of the results from all branches. This becomes especially important with truly integrated modeling. **A branch and lab-wide assessment of physical modeling capabilities, needs, and desires would enable greater consistency in how models are used.**”

“The long history of modeling within this branch can lead to focus on several topics, perhaps at the expense of leveraging the tools for other applications. The Lab leadership should find relatively inexpensive ways to enable this branch to broaden horizontally by increasing cross-branch collaborations, especially with the monitoring with the OSAT branch and the “ecology and food webs” with the Ecosystem Dynamics branch. In general, when one does integrated or coupled bio-physical modeling, it is assumed that the physics is very well modeled and that the physics represented is not specific to the coupled modeling but represents the physics of the system. **The more the physics, and ecology, can be cross-fertilized between projects and between branches, the better the results from both branches will be.** With new leadership at the Lab and in the IPEM branch, this is a window of opportunity to push these collaborations. Success will benefit everyone.”

“IPEMF being ultimately responsible for developing tools and bringing research to operations they should be coordinating the cross-theme dialogue, which seems to be a bit lacking (for eg: 1) ecological modelling work presented in ECODYN should be in IPEMF; 2) modellers should guide other groups on the kind of data required for model initialization, validation and as required for assimilation purpose.”

- 4.) The IPEMF research group should improve steps to document their model inventory and capabilities. The Branch should consider taking this time of transition in leadership and turnover of senior scientists to take stock in past and present integrated modeling efforts internally along with parallel efforts of groups doing similar work to determine if critical niches in Great Lakes modeling are not being addressed. In developing any potential new research themes and model development, the IPEMF group should consider steps necessary to document the rationale behind choosing existing models, or why there was a need to develop a new one when necessary.

“The Lab and the modeling of this branch have a long-history in the Great Lakes. This is both a good thing and potentially a limiting thing. It allows for the development, testing, and improvement of the models, as they are used repeatedly over time and across projects. But also creates inertia to continue these particular areas of modeling (research and development going too vertical within few topics at the expense of exploring diverse topics). This can result in a long and productive effort, but on a relatively narrow set of models and problems. I am not suggesting that ongoing modeling be stopped. **A small effort to create an**

inventory of the models, how they have evolved over time, switches made to different models, skill assessment, etc., would provide the basis for then seeing how they intersect with the emerging issues and with the activities and projects of the other branches. A parallel effort can also be made to cross-compare these models with what others are using (their scales, features, etc.) for similar problems.

“Some of my recent experiences with applied modeling (restoration in my case) have emphasized how important documenting why the final model used was selected: off the shelf, modified from earlier version, fused from other models, or developed from scratch. This is a step in the modeling process that has been traditionally ignored by modelers. With the greater involvement of stakeholders and the greater availability of various models (e.g., open source, friendlier software) and modeling software libraries, the selection of the model becomes important for credibility later on when the results are presented.

Modelers go through a careful thought and evaluation process before investing in a specific model and model implementation (e.g., grid resolution) for a problem. This needs to be clearly documented and articulated as part of the projects. Otherwise, when the model is presented, why that model was used looks arbitrary or simply based on convenience (e.g., easily available, investigator used it before).

Inclusion of stakeholders in the model selection phase would be beneficial for credibility when the results are presented, but the stakeholders only offer advice and do not determine what model is used.”

Division wide General Comments:

The following is a general summary of comments provided by the panelists that did not necessarily fall into research topics and/or were reflective of a Division-wide attribute.

The review panel would like to thank all of the Division managers and scientists for the excellent summary of science and engineering being conducted at GLERL. Clearly, the work being done at GLERL is of high quality, relevance and performance. The workforce is talented and motivated. The science is clearly aligned with Agency mission and regional priorities. Stakeholder review and input was overwhelmingly positive. Data collection and modeling conducted at GLERL literally saves lives in the view of the Coast Guard!

GLERL is uniquely positioned with great opportunities in the future. The division has a strong history of leadership in environmental monitoring, modeling and ecosystem forecasting. The need for the tools being developed at GLERL will only increase as stressors of ecosystems such as those related to climate change continue to manifest themselves in the Great Lakes.

The panelists reviewing the research programs at GLERL had predominately positive comments, but some common themes for recommendations emerged:

- Steps should be taken to improve the cross-pollination and interoperability of the Branches. Scientists and staff members from GLERL even commented to reviewers that “stove pipes” exist among Branches and they felt like performance could be enhanced if apparent boundaries were broken.
- There should be a concerted effort to more transparently document models and provide data to the public. The panel heard several examples of historic datasets that are not readily available to scientists outside of GLERL or the general public.
- It is very important for the Lab to continue the geophysical monitoring programs. Only a government agency can hope to get the commitment and funding to keep up monitoring programs for long periods of time. For example, monitoring the invasive species counts is necessary to figure out how the population changes both temporally and spatially. Monitoring is an important activity that should be appreciated and continued.
- While it is perfectly understandable and expected that GLERL would focus on the Great Lakes, there was a consensus by all reviewers that expanding publications and scientific interactions with societies outside of the Region could be of benefit to both GLERL as well as audiences outside of the Great Lakes.

Finally, as a cooperating entity, CILER provides a fantastic opportunity to collaborate with scientists in the region and is critical for the ongoing success of GLERL. CILER is a mechanism to receive field, laboratory, and modeling personnel assistance and support which is flexible and responsive to changing needs. In addition, this mechanism aids in the education and training of the next generation of scientists and provides energetic individuals with new skills and abilities. However, there are several vulnerabilities for GLERL associated with this mechanism: 1.) due to the large amount of personnel and skills support that is obtained from CILER, the Division would be extraordinarily impacted if not available; 2.) A large amount of funding for CILER comes through the Great Lakes Restoration initiative (GLRI) which can be reduced or terminated at any

time; 3.) Because of the close interaction with institutes within the agreement there is a potential vulnerability of CILER representing itself as a government spokesperson or entity; and 4.) potential appearance of personal services. It was difficult at times to understand where the lines between GLERL and CILER existed. While this makes a strong and collaborative work environment, it could also potentially at least give the **impression** of improprieties in government contracts/agreement regulations and policies. While there was certainly no observations of improprieties, it is a vulnerability that if not actively managed could endanger the agreement. It may be useful to seek an internal NOAA audit of the agreement and practices to determine what (if any) steps may be necessary to mitigate any potential risks.